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Calcium silicate (sandlime, flintlime) brickwork

This digest gives guidance on selection of the appropriate classes of calcium silicate bricks and mortars for use in a wide range of conditions of loading, dampness and freezing, internally and externally, above and below ground level. The disposition and methods of forming movement joints, and of making junctions with other materials, are described.

Identification

Generic name

Calcium silicate bricks consist of a uniform mixture of sand, or uncrushed siliceous gravel, or crushed siliceous gravel or rock, or a combination of these, with a lesser proportion of lime, mechanically pressed and the materials chemically bonded by the action of steam under pressure. Suitable pigments may also be included.

Sandlime describes bricks in which only natural sand is used with the lime.

Flintlime bricks contain a substantial proportion of crushed flint.

Classes

BS 187 : Part 2 specifies classes of calcium silicate bricks according to their compressive strength and drying shrinkage (*see* Table 1). The class numbers are a legacy of the values for compressive strength previously quoted in imperial units, viz compressive strength = class number × 1000 lbf/in² (approx).

Uses and limitations

Subject to selection of the appropriate class of brick and mortar, these bricks can give satisfactory service in a wide range of conditions of loading, dampness and freezing, internally and externally, above and below ground (*see* Fig 1 and Table 1). Most manufacturers offer sandlime and flintlime bricks in many colours in each of several classes.

All calcium silicate bricks, except those of Class 1 (which should not be used in wet conditions), are resistant to attack by most sulphate salts in soil and groundwater but where these are present the vulnerability of the mortar to attack must be considered. The bricks may be attacked by high concentrations of magnesium sulphate or of ammonium sulphate sometimes present in industrial wastes used for filling sites. If contaminated by chlorides, eg calcium chloride, common salt or seawater, all classes are liable to suffer if attacked by severe frost.

The drying shrinkage of calcium silicate bricks calls for care in design, in storage and during building—unless they are to be used in permanently damp conditions.

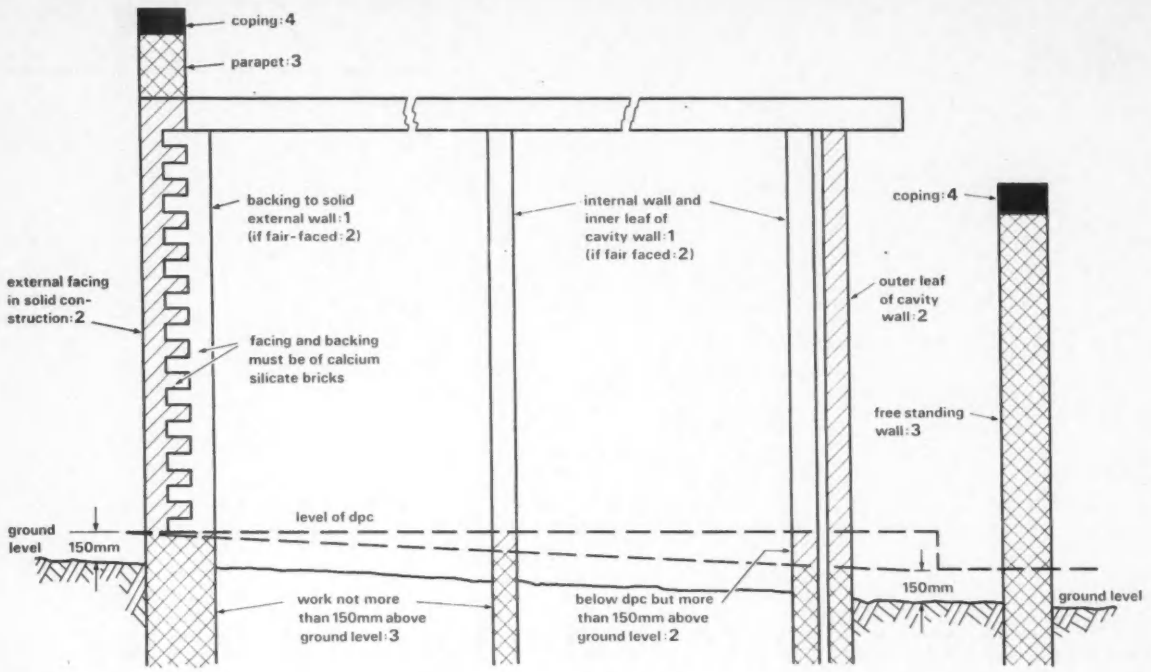
coping:4
parapet:3
backing to solid external wall:1 (if fair-faced:2)
internal wall and inner leaf of cavity wall:1 (if fair faced:2)
coping:4
external facing in solid construction:2
facing and backing must be of calcium silicate bricks
outer leaf of cavity wall:2
free standing wall:3
ground level
150mm
level of dpc
work not more than 150mm above ground level:3
below dpc but more than 150mm above ground level:2
150mm
ground level

Fig 1 Minimum classes of calcium silicate bricks for various positions

Description

Constituents

Sand and flint aggregates are the major constituents and their suitability depends on the grading, the nature of the surface of the grains and any coatings on them, and the amounts of impurities present. The properties of the aggregates have an important influence on the quality of the bricks.

Either quicklime or hydrated lime is used but hydration must be complete before the bricks are pressed, to avoid expansion during subsequent steam treatment.

Suitable pigments can be incorporated in the mix and a high proportion of the bricks now made in this country are coloured in this way.

Manufacture

Mixing processes vary according to whether ground quicklime or hydrated lime is used. In the *silo or reactor process* ground quicklime and sand are mixed, usually in a screw or pan mixer, with an excess of water beyond that required to hydrate the lime; the mix is then stored in the silo for 3 to 24 hours to hydrate before being remixed and passed to the press. In the *drum hydration* process, ground quicklime and sand are mixed with a small excess of water over that required for hydration of the lime in a large revolving drum, in the presence of low-pressure steam which increases the temperature and so accelerates hydration. A pan mixer, or a rod mill, is then used to complete the mixing and to incorporate the remaining water necessary for pressing. In processes using dry hydrated lime, the sand and lime are mixed directly in the mixer or mill with the necessary water for pressing.

The bricks are then shaped under high mechanical pressure and put into hardening chambers (autoclaves) into which steam is slowly admitted until the required pressure is attained. The steam pressure is maintained for 4 to 15 hours according to the steam pressure used.

Associated materials

Mortar mixes for use with all classes of brick in various situations are set out in Table 2 (*see also* Digest 58).

Calcium silicate bricks do not impose any restrictions on the selection of materials to be used for dampproof courses, flashings, ties, metal fastenings etc with which they might be in contact.

Shape and size

Accurate shape and size and square arrises are normal with this type of brick.

Table 1

CLASS	BS 187 : Pt 2 requirements: Average compressive wet strength MN/m^2	BS 187 : Pt 2 requirements: Maximum drying shrinkage % *of original wet length*	Suggested uses (it is permissible to use a stronger class of brick than is indicated)		Preferred mortar group for class of brick: Frost risk during construction: *none*	Preferred mortar group for class of brick: Frost risk during construction: *present*
1	7·0	Not specified	Internal walls	Not available in facing quality	v or iv	iv (air-entrained) or iii
			Inner leaf of cavity walls		iv	iii
			Backing to solid external walls			
2	14·0	2A 0·025 2B*0·035	External walls, outer leaf of cavity walls and facing to solid walls: work below dpc but only if more than 150 mm above ground level		iv	iii
3	20·5	3A 0·025	Parapet walls, rendered	Brickwork liable to be continuously saturated with water (but not chloride solutions, *see* text) or to be subjected to freezing when saturated	iv	iii
		3B*0·035	Parapet walls not rendered; external free-standing walls and work below 150 mm above ground level		iii	
4	27·5	0·025	Sills and copings; earth-retaining walls back filled with free-draining material	Unprotected brickwork below ground—but if sulphates are present sulphate-resisting mortar is required	ii	ii
5	34·5	0·025	Calculated load-bearing brickwork wherever these high strengths are essential		to be specified by designer	
7	48·5	0·025				

*Not to be used where the high drying shrinkage would increase the risk of crack formation. Suitable therefore for piers, unrestrained or partially restrained infill panels of short length and short internal walls not restrained at both ends. Not to be used with mortars stronger than group iv—except that group iii may be used when there is risk of freezing.

Table 2 Mortar mixes (proportions by volume)

	Mortar group	Cement : lime : sand	Masonry-cement : sand	Cement : sand, with plasticiser
Increasing strength but decreasing ability to accommodate movements caused by settlement, shrinkage, etc ↑	i	1 : 0–¼ : 3	—	—
	ii	1 : ½ : 4–4½	1 : 2½–3½	1 : 3–4
	iii	1 : 1 : 5–6	1 : 4–5	1 : 5–6
	iv	1 : 2 : 8–9	1 : 5½–6½	1 : 7–8
	v	1 : 3 : 10–12	1 : 6½–7	1 : 8

Direction of changes in properties:
- equivalent strengths within each group →
- increasing frost resistance →
- improving bond and resistance to rain penetration ←

Where a range of sand contents is given, the larger quantity should be used for sand that is well graded and the smaller for coarse or uniformly fine sand.

Because damp sands bulk, the volume of damp sand used may need to be increased. For cement : lime : sand mixes, the error due to bulking is reduced if the mortar is prepared from lime : sand coarse stuff and cement in appropriate proportions; in these mixes 'lime' refers to non-hydraulic or semi-hydraulic lime and the proportions given are for lime putty. If hydrated lime is batched dry, the volume may be increased by up to 50 per cent to get adequate workability.

The work sizes and co-ordinating sizes (ie inclusive of mortar joint) of bricks to BS 187 : Part 2 are shown in Fig 2. The Standard specifies the following limits of manufacturing sizes:

	maximum *mm*	minimum *mm*
length	217	212
width	105	101
height	67	63

Bricks of co-ordinating sizes are available from some manufacturers. The sizes are likely to follow the recommendations of DD . . . *Clay bricks with modular dimensions* (in course of preparation) viz:

Designation	Work sizes length	width	height
mm	*mm*	*mm*	*mm*
300×100×100	290	90	90
200×100×100	190	90	90
300×100×75	290	90	65
200×100×75	190	90	65

Weight

Calcium silicate brickwork as laid weighs about 2 tonnes per cubic metre (= 2 kg/m² per mm thickness).

Appearance

The basic colours are white, off-white, cream or pale pink but facings are available in various pastel shades and darker hues. The white bricks in particular provide moderately good light reflectance when laid flush as facings to internal surfaces or to light wells and enclosed courts, without further applied decoration. All the colours deepen considerably when wet.

The surfaces of sandlime bricks are usually smoother than clay bricks but textured facings are available from some makers.

All bricks except those of Class 1 are required by the Standard to be free from visible cracks and noticeable balls of clay, loam and lime.

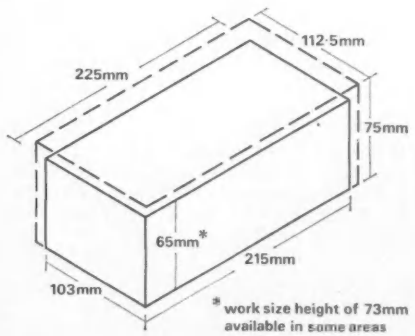

Fig 2 Work sizes (firm lines) and co-ordinating sizes (broken lines) of bricks to BS 187 : Part 2

Characteristics

Strength

The strengths given in Table 1 are average compressive strengths when wet; the strength of dry calcium silicate bricks is 30–50 per cent higher than when saturated.

Fire resistance

Schedule 8 of the Building Regulations 1972 groups together clay, concrete and calcium silicate brickwork as having the same order of fire resistance.

Gases

The only gases normally present in the atmosphere which affect calcium silicate bricks are sulphur dioxide and carbon dioxide. Prolonged exposure to moist air containing sulphur dioxide decomposes the hydrated calcium silicate cementing agent and forms finally a skin of calcium sulphate (gypsum) and hydrated silica. Above ground, atmospheric carbonation, which occurs in depth slowly with age, slightly increases the strength but causes slight shrinkage.

Liquids

Absorption The total water absorption is usually 7–16 per cent (by weight), similar to some clay, other than engineering, bricks.

Moisture movements The drying shrinkage of bricks to BS 187 : Part 2 should not exceed 0·025 per cent of the original wet length, except for bricks of classes 2B and 3B for which the limit is 0·035 per cent and class 1 for which no limit is specified (*see* Table 1). Subsequent expansion on wetting is likely to be about the same.

Thermal

Thermal conductivity The thermal conductivity (*k* value) of masonry of density 2000 kg/m³ (from IHVE Guide) is:

at 1% moisture content* (= 'protected' situations):
0·92 W/m °C

at 5% moisture content* (= 'exposed' situations):
1·24 W/m °C

*moisture content by volume

Thermal expansion The coefficient of linear expansion is about 8 to 14 $\times 10^{-6}$ per °C, which is about one-and-a-half times that of fired clay bricks. This value is for the material in the unrestrained condition and for an area of walling it will be rather less.

Durability

The resistance of calcium silicate bricks to frost action is related mainly to their mechanical strength and this has been taken into account in making the recommendations set out in Table 1 and Fig 1.

They normally contain no soluble salts such as produce efflorescence on some clay bricks.

Exposure to salt spray causes some erosion of the surface, probably as a result of the repeated crystallisation of the salt with which they become impregnated, with alternate wetting and drying. They are not recommended for use where liable to exposure to sea-spray.

Working characteristics

The bricks can be cut readily to form closers etc but purpose-made bricks to BS 4729 : 1971 can be obtained for many special purposes and, when available, should be used particularly in facing work.

The bricks do not take nails or screws directly, but they are easily drilled to receive plugs for these; they will quickly take the edge off masonry drills unless the detritus is cleared regularly from around the drill point.

Design

Movement joints

Below damp-proof course Brickwork below damp-proof course usually remains fairly wet; moisture movement, if any, is very slight and movement joints are not normally required.

External walls Vertical movement joints should be provided above damp-proof course at intervals of 7·5–9 m, subject to the shape of the panel and the disposition of any openings. The lines at which changes in height or thickness occur are lines of potential cracking; the higher the proportion of the length of a panel to its height, the greater is the risk of cracks developing in it.

Permanent movement joints, to remain in place throughout the life of the building, are formed by butting the bricks against a suitable separator, eg a 10 or 13 mm thick strip of joint filler, or bituminous felt, polythene sheeting or building paper, and pointing with a suitable mastic or sealant of matching or contrasting colour. They are always visible since, unless they have been constructed in toothed form, they break the bond but it is sometimes possible to locate them so that they are to some extent masked by an architectural feature. Where the use of non-setting mastic is undesirable, for example where it might be subject to deliberate damage, the joint may be pointed with mortar but this should be done as late as possible in the construction of the building. Alternatively, a self-curing sealant may be used but this may be more expensive; if so, its use is likely to be confined to the lowest one or two metres of walling.

An alternative method of forming a straight vertical joint is to leave a 10 mm gap severing the wall. A convenient way of doing this is to build in three thicknesses of 3 mm plywood or hardboard, the middle strip being wider and left projecting to allow for easy removal and release of the other two. The gap is then sealed with a preformed strip mastic or with pre-compressed foamed plastics.

Probably the least conspicuous method is to incorporate a continuous strip of clear polythene sheeting, say of 250 gauge, and of the same width as the thickness of the brick leaf or wall, following the mortar joints in toothed fashion.

Temporary movement joints may be left during construction, until the initial 'settling down and drying out' period is over. The joints are toothed to follow the bond or lap of the brickwork and formed with a mortar of low strength, eg a 1 : 3 to 1 : 4½ mix (by volume) of non-hydraulic lime and sand. After drying and settling down, the lime–sand mortar joints are deeply raked out and repointed with the same mortar as used in the rest of the work.

Permanent joints are preferred if the brickwork is to be pointed as the work proceeds.

Internal walls Internal walls built in mortar mix v (Table 2) do not require movement joints provided that they can be allowed to dry out before plastering. If, however, they must be plastered before the brickwork has dried out, or if they are built in a stronger mortar, movement joints should be provided.

Stability Care should be taken to ensure the stability of walls, especially those straight on plan, both during and after construction. Where necessary, sleeved dowels of constant cross-section, or other suitable fixings, may be used to span the movement joints, giving lateral support without restraining movement in the plane of the wall.

Junctions with other walling materials

Where calcium silicate bricks are to be used for one face of a solid wall, the bricks used for backing and for the other face should also be of calcium silicate or other material of comparable drying shrinkage and not clay bricks.

Where clay bricks are to be used in conjunction with calcium silicate facings, it is necessary to cater for differential movement between the two materials by constructing the wall in two leaves. These may be tied together with the normal complement of butterfly type wall ties but they must be separated, including all edges, with, for example, polythene sheeting or a cavity. If the cavity is to be narrower than 50 mm, special measures should be taken to avoid filling it with mortar. A separating membrane should be provided around all openings. The vertical damp-

proof course of bituminous felt or polythene normally used in these positions in cavity external walls will generally perform this function but it is necessary to separate the two walling materials even where a vertical damp-proof course is not otherwise required. Cavity construction has a number of advantages for external walls, including better resistance to the weather; irrespective of the type of brick used, even a one-and-a-half brick thick solid wall, unless it is rendered externally or clad, will not be sufficiently resistant to rain penetration except in sheltered conditions.

All internal walls of calcium silicate brickwork, even those on upper floors, should be bedded on a damp-proof course or a strip of polythene sheeting. At all levels where clay bricks are bedded on calcium silicate brickwork, a similar measure should be taken so as to allow small longitudinal sliding movements to occur without undue restraint.

New brickwork should not generally be toothed and bonded to existing; a straight vertical movement joint, as previously described, should be interposed. This will allow the normal differential movement between the old work and the new to occur without adverse effect.

Junctions with concrete

Concrete-encased or reinforced concrete beams, lintels or slabs should not be bedded or cast directly on to calcium silicate brickwork, particularly facing brickwork, since the restraint afforded by the concrete may encourage the brickwork to crack, or differential movement between the concrete and the brickwork may cause a ragged horizontal crack at the junction. The two materials should be separated by, for example, two thicknesses of polythene sheeting; the special polythene sheeting made to give a low coefficient of friction is particularly suitable for this. For the slip plane to be fully effective, the top of the wall should be flushed up with mortar, trowelled smooth and allowed to harden, before the slip plane and concrete are placed. In external walls, a waterproof membrane at this level will also reduce or eliminate temporary darkening of the brickwork by wetting and any staining by lime or other substances that may be leached out of the concrete by the weather. A further precaution against these effects is to place a projecting drip of a stiff material (which may extend to the full width of the wall or leaf to act as the slip plane) at the junction; this will also help to prevent grout runs when casting in situ concrete. If considerations of lateral stability so dictate, the slip plane may be pierced at intervals and bridged vertically by butterfly type wire wall ties.

It is not advisable to place, or cast in situ, concrete encased or reinforced concrete columns directly against calcium silicate brickwork, or even to 'butter' the brickwork against the columns with mortar. The two materials should be separated by a slip plane, as described above.

When building up to the underside of beams or slabs, bituminous felt or some similar material should be interposed. If necessary for lateral stability, the sheeting may be pierced at intervals and bridged by wire ties, or some other suitable measures taken. For example, to assist with lateral restraint at the tops of walls, channels a little wider than the thickness of the wall can be formed in the concrete soffits and the brickwork built into them. Alternatively, dovetailed masonry fixings, consisting of proprietary slots and anchors, could be used. The metal slots should be cast into the concrete, so as to allow movement in the direction of the wall length, and the anchors placed at about 600 mm (maximum) centres. The anchors can be inserted in the slots as bricklaying proceeds, taken through the slip plane and bedded in the vertical joints of the brickwork.

Copings

If a brick-on-edge coping is to be used at the top of an external wall, a continuous damp-proof course of stiff material should be bedded immediately under the coping and should project to form a drip 25 mm or more beyond each face of the wall. A concrete coping (as BS 3798), preferably wide enough to oversail each face of the brickwork by about 50 mm and drip throated, used in conjunction with a damp-proof course, will give better protection than a brick-on-edge coping.

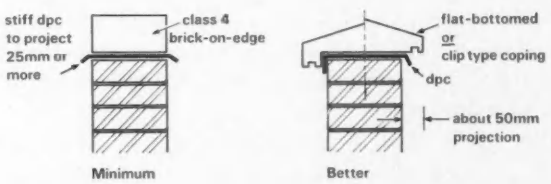

Fig 3 Copings

Applied finishes

Tiling, plastering and rendering should not be carried over permanent movement joints, or across any junction with a different material where relative movement is to be expected. At these points each coat of plastering or rendering should either be severed by a straight cut, before the work hardens, or worked up to each side of a batten, temporarily or permanently secured at the edge of the joint. The joints can be covered by battens and strips (fastened to one side only of the joint) or by patent coverings, or filled with a sealant or mastic. Similar measures should be taken with wall tiling.

Sitework

Storage

To minimise drying shrinkage, the bricks should be reasonably dry when laid. Where manufacturers take steps to ensure delivery in such a condition, the benefit will be largely lost if the bricks are allowed to become wet on the site. They should, therefore, be stacked under cover or protected from rain by covering with polythene sheeting or other waterproof material.

Laying

Individual makes and classes of brick vary in their suction and absorption characteristics and the craftsman must adjust his technique accordingly. Bricks of high suction may need to be dampened before laying, particularly during hot weather, to prevent too much water being removed from the mortar; or, better, the consistency of the mortar should be adjusted to suit the suction of the units, if necessary by using water-retaining admixtures, rather than wetting the units to suit the mortar.

Protection after laying

Partly completed work, left overnight or longer, should be protected from rain.

Cleaning and maintenance

Grease, oil and general dirt can be removed with a scrubbing brush and warm water containing detergent.

Ordering

When ordering, the purchaser should specify:

class
size
whether required for facing
colour
texture
if certification to BS 187 : Part 2 is required

Further information

British Standards Institution

BS 187 Part 2 : 1970 (Metric units) *Calcium silicate (sand-lime and flintlime) bricks*

CP 121 Walling: Part 1 *Brick and block masonry*

PD . . . (in course of preparation) *Guide to specifying the quality of building mortars*

BRE Digests

49	*Choosing specifications for plastering*
55–57	*Painting walls*
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61	*Strength of brickwork, blockwork and concrete walls*
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108	*Standardised U-values*
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Other HMSO publications

Advisory Leaflet No 27 *Rendering outside walls* (DOE)

Winter building (DOE)

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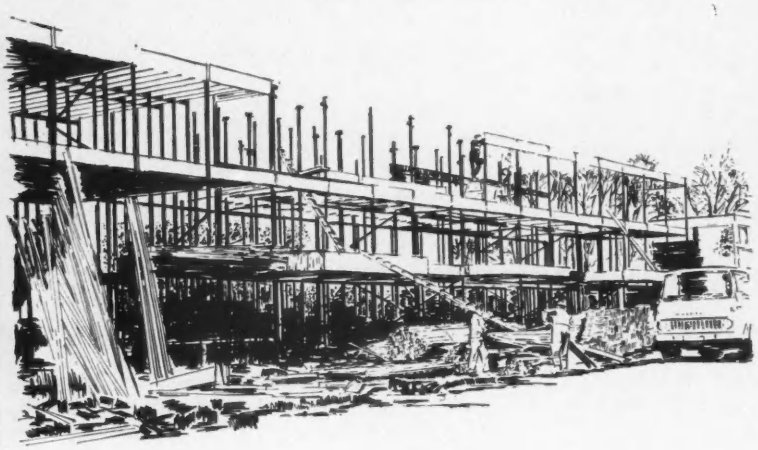

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